7.4.64 EEC A

S38

For E.E.C.

Experimental Proposal
Group 860
Limited Distribution

7 April, 1964

EXPERIMENT ON INELASTIC PROTON - PROTON SCATTERING USING THE SLOW EXTRACTED PROTON BEAM

G. Bellettini, G. Cocconi, A.N. Diddens, E. Lillethun,
J.P. Scanlon, J. Walters and A.M. Wetherell

An experiment to study the process $p + p \rightarrow p + p^*$ (p^* being an excited nucleon state or isobar) using the slow extracted proton beam is proposed. Measuring the momentum spectra of high energy scattered protons at the angles 20, 60 and 160 mrad simultaneously and at incident momenta between 3 and 12 Gev/c would give data for the study of the following points:

(1) The existence and properties of a new proton resonance of mass 1400 Mev$^{1,2)}$. The previous p - p experiment$^{1)}$, which found a bump corresponding to a resonance of mass 1400 Mev, indicated a rather rapid decrease with momentum transfer in the excitation of this state. The behaviour was in fact similar to that of the (3/2,3/2) state. A π - p experiment$^{2)}$, however, definitely assigned isospin $^1/2$ to a state at mass 1400 Mev. If the bump seen in the p - p experiment is an excited nucleon state of isospin $^1/2$, the excitation in p - p collisions is different from that found already for the (1/2,3/2) and the (1/2,5/2) states. The p - p data may give a hint that two different kinds of nucleon resonances exist and it seems important to establish firmly the experimental situation by further p - p experiments.

(2) The excitation of the (3/2,3/2) state as a function of energy and momentum transfer relative to that of the (1/2,3/2) and (1/2,5/2) states. A previous internal beam p - p experiment$^{1)}$ at 60 mrad scattering angle studied the excitation of the three well-known isobars over a range of t from about -0.05 Gev^2 to -0.20 Gev^2.

The present experiment would allow this range to be extended to larger and to smaller t values, firstly because of the provision of smaller and larger scattering angles 20 and 160 mrad and secondly because of the much better background situation obtained from the use of a liquid H_2 target rather than CH_2 and C targets. The energy and momentum transfer dependence of the excitation of the resonances remains an important question in the study of the mechanism of the production of the states. The small angle (20 mrad) data of the proposed experiment would be of particular interest in discussions of the angular momentum changes needed to generate the $3/2^-$ and $5/2^+$ isospin 1/2 states. The 20 mrad data from this experiment would extend the information which may be obtained from a current experiment on very small angle p - p scattering ($\Theta \lesssim 15$ mrad).

(3) The cross sections for production of the (1/2,3/2) and (1/2,5/2) states at large momentum transfers relative to the elastic scattering cross section. An experiment at 110 mrad scattering angle$^{3)}$ has given an indication that the cross sections for excitation of these states follow the trend of the elastic p - p cross section as a function of t to t values as large as -2.2 Gev^2. The recent Cornell - Brookhaven experiments$^{4)}$ on high momentum transfer wide angle elastic scattering showed a statistical type of behaviour. It would be interesting to follow the isotopic spin 1/2 states momentum transfer as far as possible to compare with the elastic scattering. The experiment proposed, measuring scattering at 160 mrad can provide data at $t = -4\ \text{Gev}^2$. Extensions to larger momentum transfer have to await the higher energy (25 Gev/c) extracted beam which will be installed so that space is available on both sides, allowing detection of decay products as well as the scattered particle.

(4) The possibility of new nucleon resonances. At 12 Gev/c the total c.m.s. energy in the p - p system is 4.93 Gev, hence in the reaction $p + p \rightarrow p + p^*$ the maximum mass available for the p^* is about 4 Gev. Rough considerations about background indicate that the present experiment would be sensitive to bumps corresponding to cross sections of the order of a few tenths of a mb / sterad for masses up to about 3 Gev. Within these limits the nucleon mass spectrum could be explored.

A schematic experimental layout is given in Fig. 1. The present slow extracted proton beam, which can operate up to 12 Gev/c for a 30 ms pulse length, bombards a 20 cm long liquid hydrogen target placed near PS magnet 4 in the South target area. Useful protection of the detectors from background is provided by the main shielding wall of the target area. The main beam is best disposed of by allowing it to pass through a channel in the neutrino shielding and on into Mount Citron. One or two quadrupoles would be sufficient to keep the beam confined within a 20 cm vacuum pipe. It may even be possible to use the beam for other purposes within the limited space left available (e.g. radio-chemistry). The other alternative for dumping the beam is to stop it in existing shielding at point A in Fig.1, although, of course, the background situation is much less clean than in the first possibility.

Three scattered particle channels at angles of 20, 60 and 160 mrad are provided and two 2 m magnets momentum analyse the particles emerging from each channel. Three counter telescopes detect the momentum analysed particles at each angle and a beam monitor telescope is provided ahead of the 160 mr magnet. The absolute intensity of the main beam is to be measured by a secondary emission chamber.

The geometry of the magnetic spectrometers and associated equipment is such that the momentum resolution obtainable is $^1/2$ - 1% and the solid angle of each counter channel 10^{-6} - 10^{-7} sterad.

Counting rate estimates in the region of the inelastic bumps associated with the excitation of the isobars, may be obtained from previous data[1,3]. At 10 Gev/c and 60 mrad the rate per channel (10^{-7} sterad) per 10^{11} incident protons 1 Gev/c below the elastic scattering peak is about 30, while at 20 mrad and the same momentum the rate is about 300. At 60 mrad a spectrum containing 50 points each with 3000 counts and covering an inelastic momentum range of 2 Gev/c could be obtained in about 3 hours, at 20 mrad an extra factor of 10 in counting rate is available. With the present uncertainties in the operational efficiency of setting up the beam it is probably wise to count about 6 hours (1 shift) for a spectrum measurement at one momentum and the small angles 20 and 60 mrad.

Estimates of counting rates for the large angle (160 mrad) spectra are much less sure, but some data from reference 3 taken at $t = -2.8 \text{ Gev}^2$ indicate that for a channel solid angle of 10^{-6} sterad a rate, in the interesting region, of about 1 event/3 bursts can be obtained. A spectrum with about 5% statistical error on each point would result in 2-3 shifts.

The time given to a specific incident momentum for data taking depends of course on what is found, an estimate can be given, however, particularly relative to the question of the 1400 Mev state. This study would need 7 runs between 3 and 6 Gev/c, taking spectra at 500 Mev/c intervals to trace out in some detail the behaviour of the 1400 MeV bump. The study of the (3/2,3/2) and $T = {}^1/2$ excitations could be well done by 7 measurements between 6 and 12 Gev/c in 1 Gev/c steps. The high momentum transfer study of the $T = {}^1/2$ excitations at momenta between 8 and 12 Gev/c and the largest angle would need an extra 8 shifts. Summing up these estimates gives a total of 22 shifts of running time. This time and the necessary facilities are requested for the last quarter of 1964.

REFERENCES

1 G. Cocconi, E. Lillethun, J.P. Scanlon, C.A. Ståhlbrandt, C.C. Ting, J. Walters and A.M. Wetherell, Proceedings Siena International Conference on High-Energy Physics 1963;

G. Cocconi, E. Lillethun, J.P. Scanlon, C.A. Ståhlbrandt, C.C. Ting, J. Walters and A.M. Wetherell, Physics Letters **8**, 134 (1964).

2 P. Bareyre, C. Bricman, G. Valladas, G. Villet, J. Bizard and J. Seguinot, Physics Letters **8**, 137 (1964).

3 A.N. Diddens, E. Lillethun, G. Manning, A.E. Taylor, T.G. Walker and A.M. Wetherell, Proceedings 1962 International Conference on High-Energy Physics at CERN, p. 576.

4 G. Cocconi, V.T. Cocconi, A.D. Krish, J. Orear, R. Rubinstein, B.D. Scarl, W.F. Baker, E.W. Jenkins and A.L. Read, Phys.Rev.Letters **11**, 499 (1963) and **12**, 132 (1964).

* * *

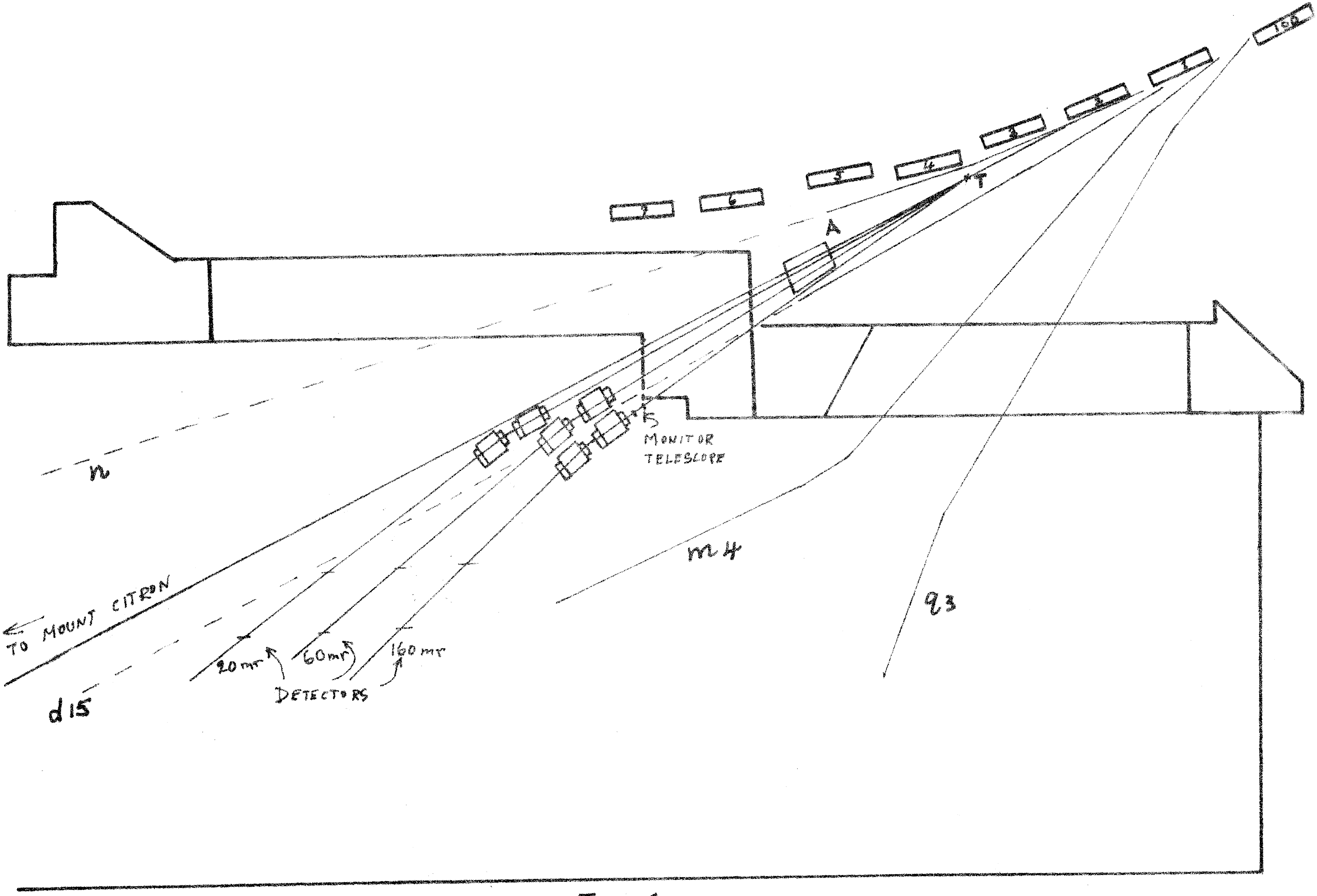
100
1
2
3
4
5
6
7
T
A
5
MONITOR TELESCOPE
n
m4
q3
← TO MOUNT CITRON
d15
20mr
60mr
160mr
DETECTORS

Fig 1